Master Thesis Presentation

Investigation of the Novel Capacitively Coupled Patch Antenna (CCPA) for Mobile Communications

By Fei Xie

Supervised by
Prof. Dr. -Ing. Klaus Solbach

September 2008

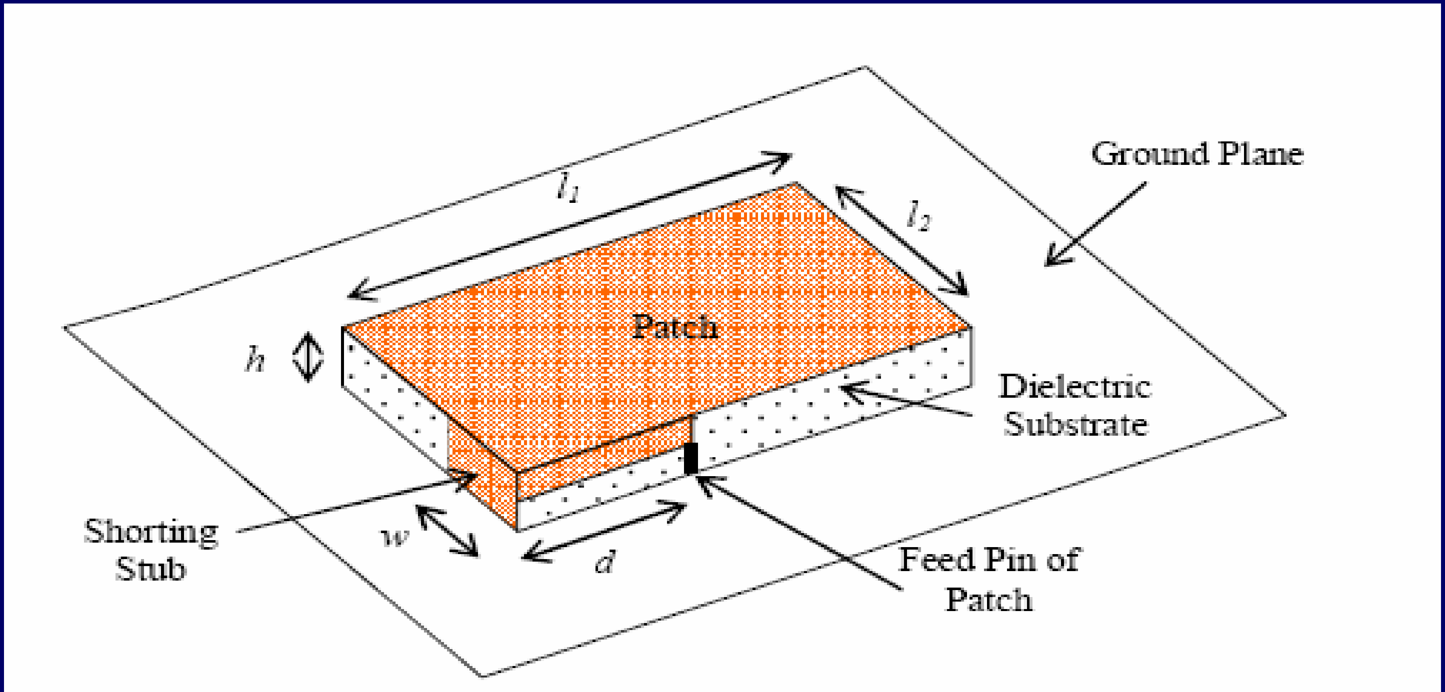
UNIVERSITÄT DUISBURG ESSEN

Contents

- Problem Introduction
- Modeling and Simulation
- Experiment and Result
- Conclusion

Problem Introduction

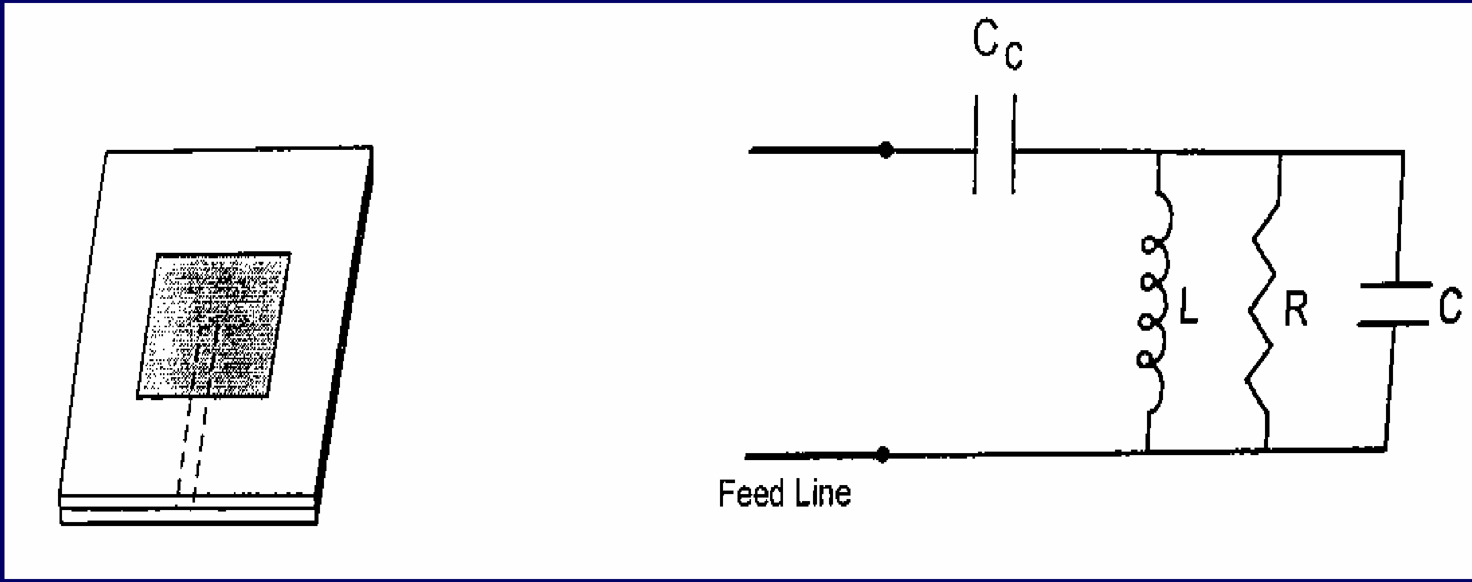
Due to the rapid development of mobile communications and miniaturization of mobile device, low profile planar inverted-F antennas (PIFA) have replaced the popularly used helical antennas of mobile handsets and systems. The PIFAs normally apply a probe feed which will introduce probe inductance to make impedance match difficult and to bring more spurious radiation in thicker substrate case.



UNIVERSITÄT DUISBURG ESSEN

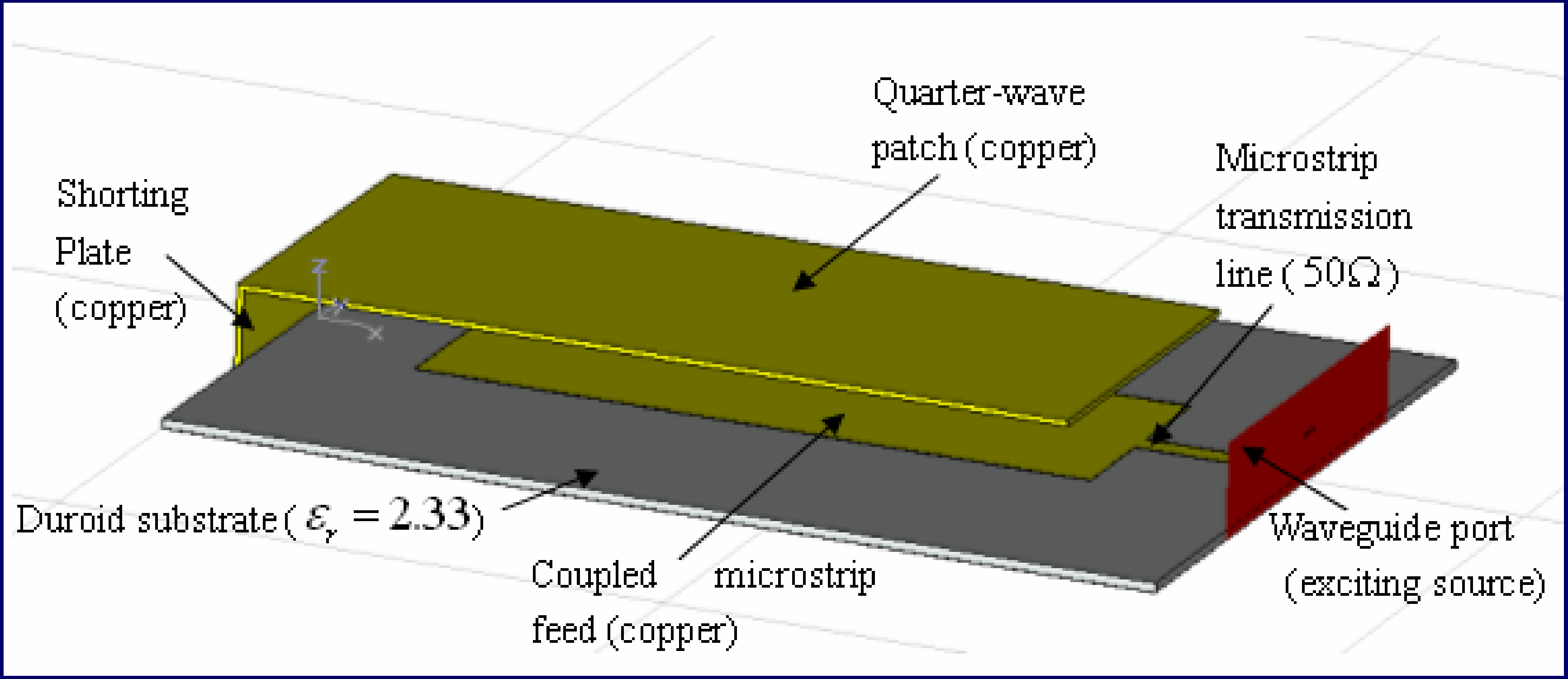
Capacitively coupled microstrip feed

One novel solution is to use capacitively coupled microstrip feed to replace the probe feed in PIFA. This feed could avoid probe inductance and raise reliability by canceling the drilling and soldering procedure of the probe feed.



Goal of study

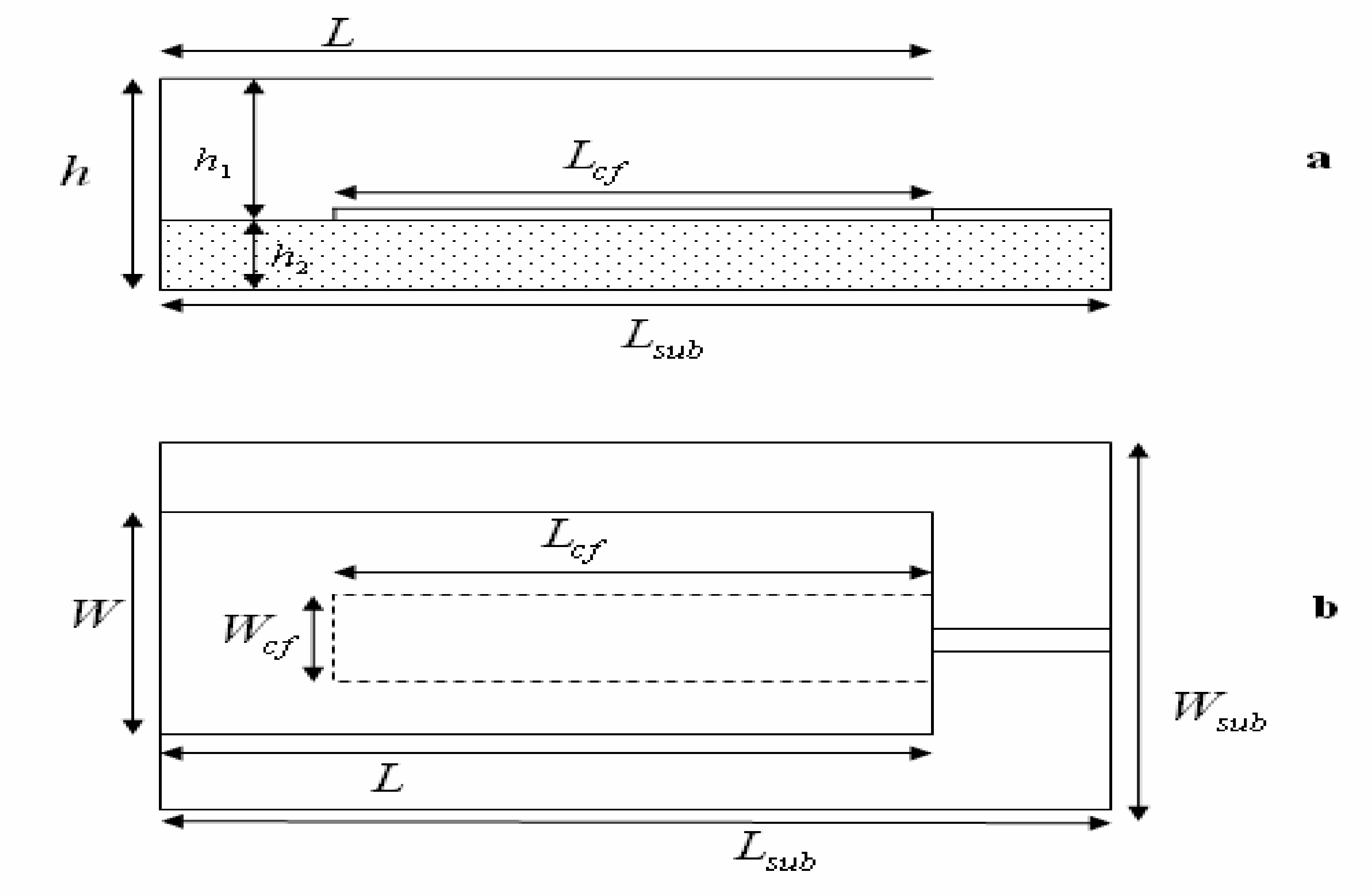
My study here is to use an underneath capacitively coupled microstrip feed to replace probe feed in PIFA on specific substrate. The goal of my study is to find out the design rules to this kind of antenna.



Modeling and Simulation

- Substrate material
  - Duroid RT5870
  - $\varepsilon_r = 2.33$
  - Loss tangent 0.0012 at around 1GHz.
  - Thickness 0.79mm
- Maximal Dimension of CCPA model
  - Length 82mm
  - Width 60mm
  - Height 7mm

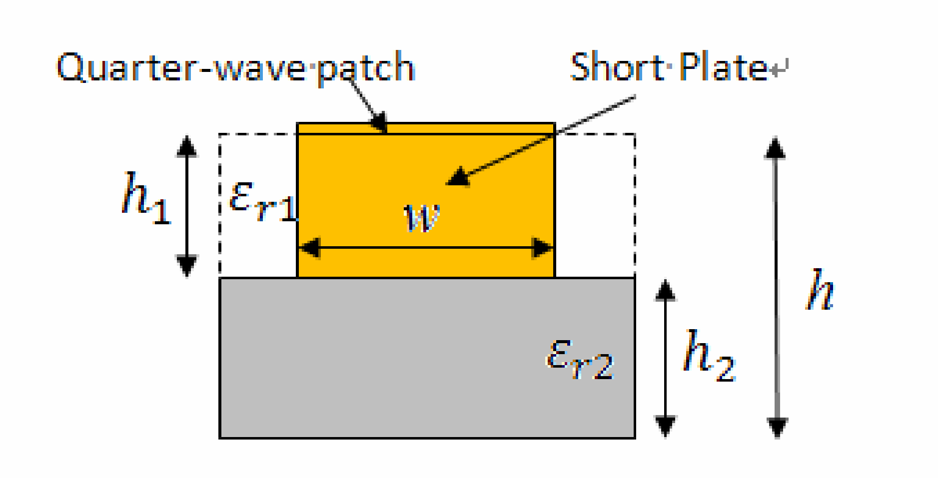
Configuration of CCPA



Design Parameters

Length of quarter-wave patch

$$L \approx \frac{c}{4 f_r \sqrt{\varepsilon_{reff}}} - h = \frac{\lambda_0}{4\sqrt{\varepsilon_{reff}}} - h$$



Width of quarter-wave patch W

Height of air h_1

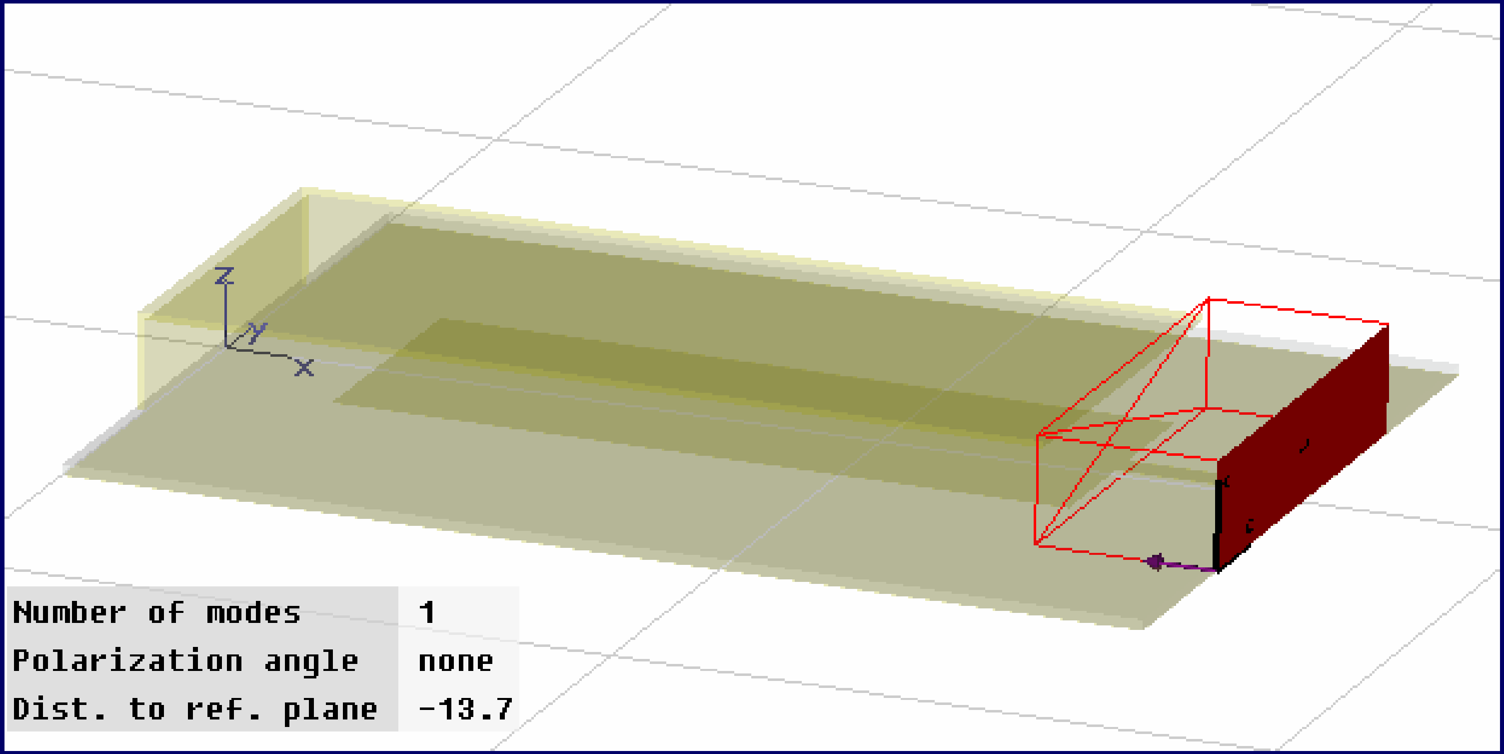
Width of coupled microstrip feed W_{cf}

Length of coupled microstrip feed L_{cf}

Reference plane

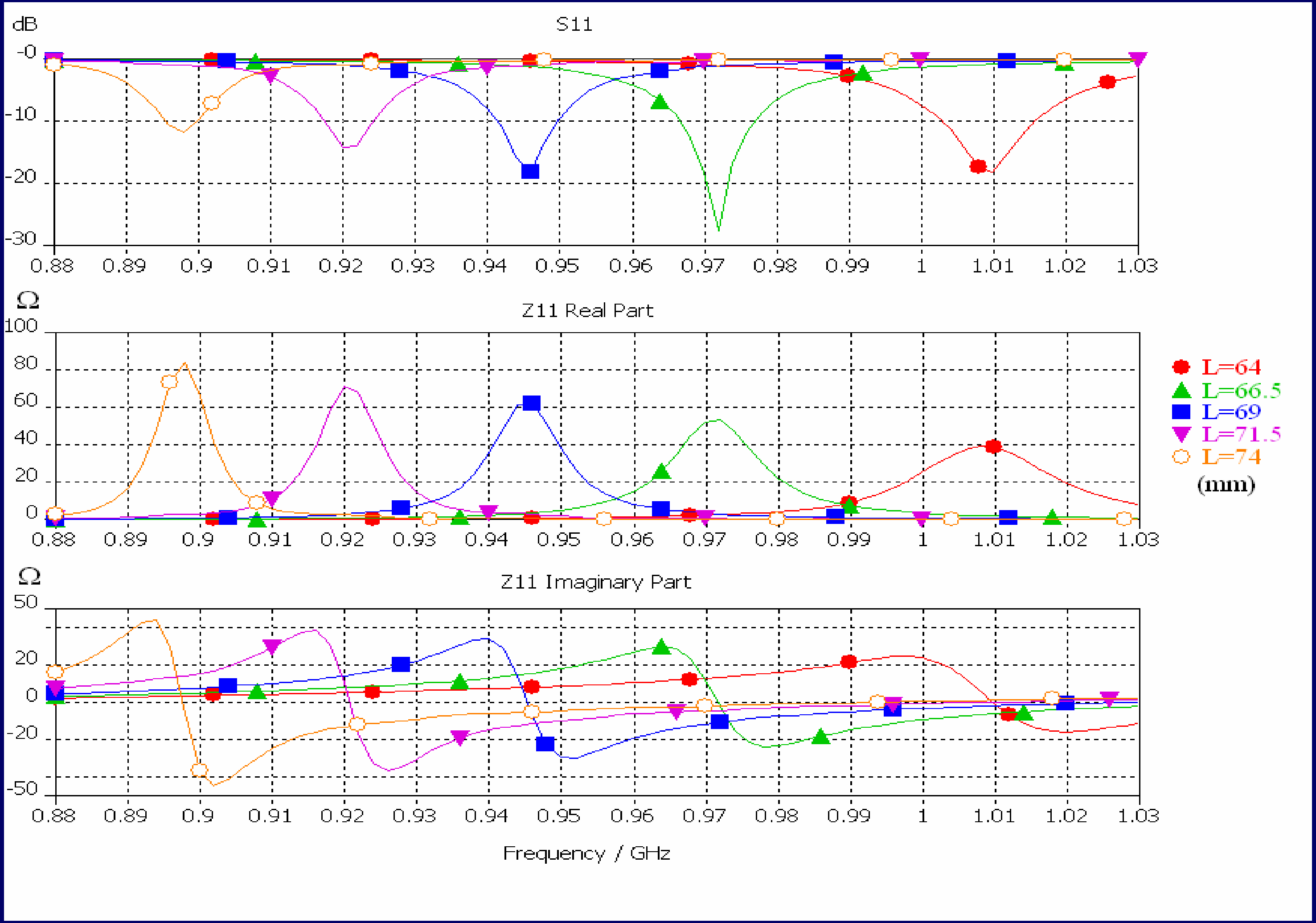
Reference plane of input impedance

$$L - L_{sub}$$



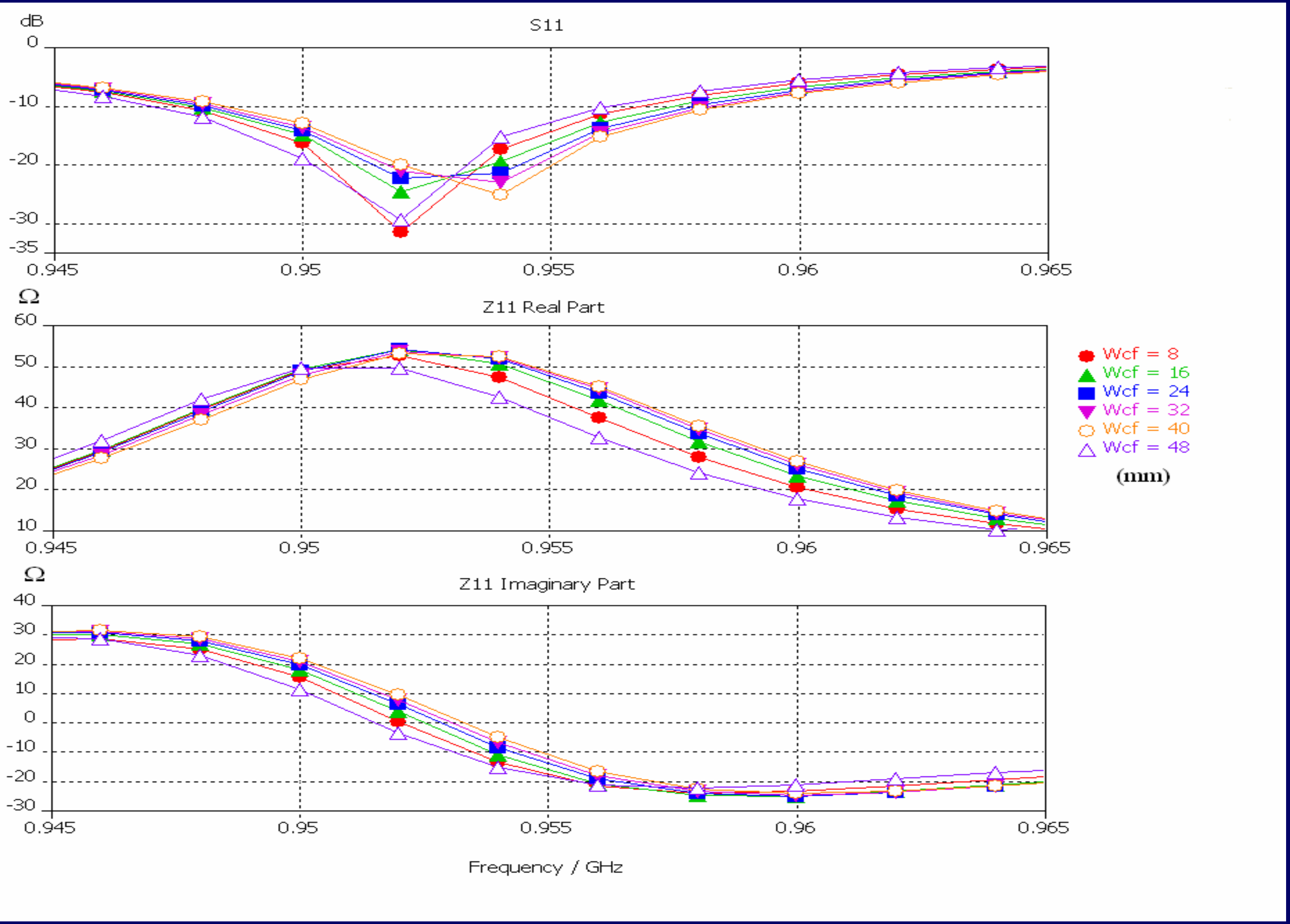
Length of quarter-wave patch

S11(dB) and Input impedance curve of CCPA vs. *L*



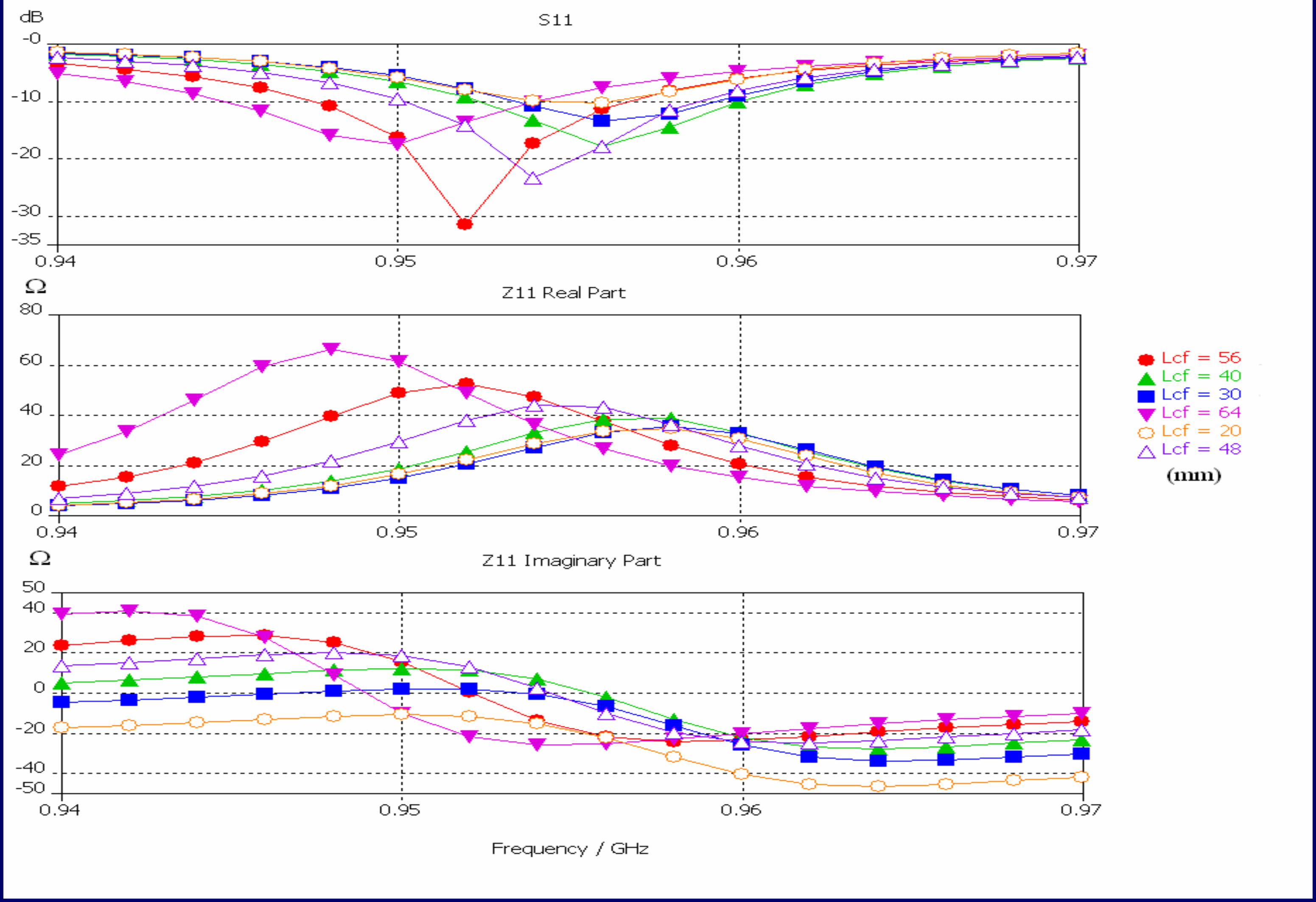
Width of coupled microstrip feed

S11(dB) and Input impedance curve of CCPA vs. W_{cf}



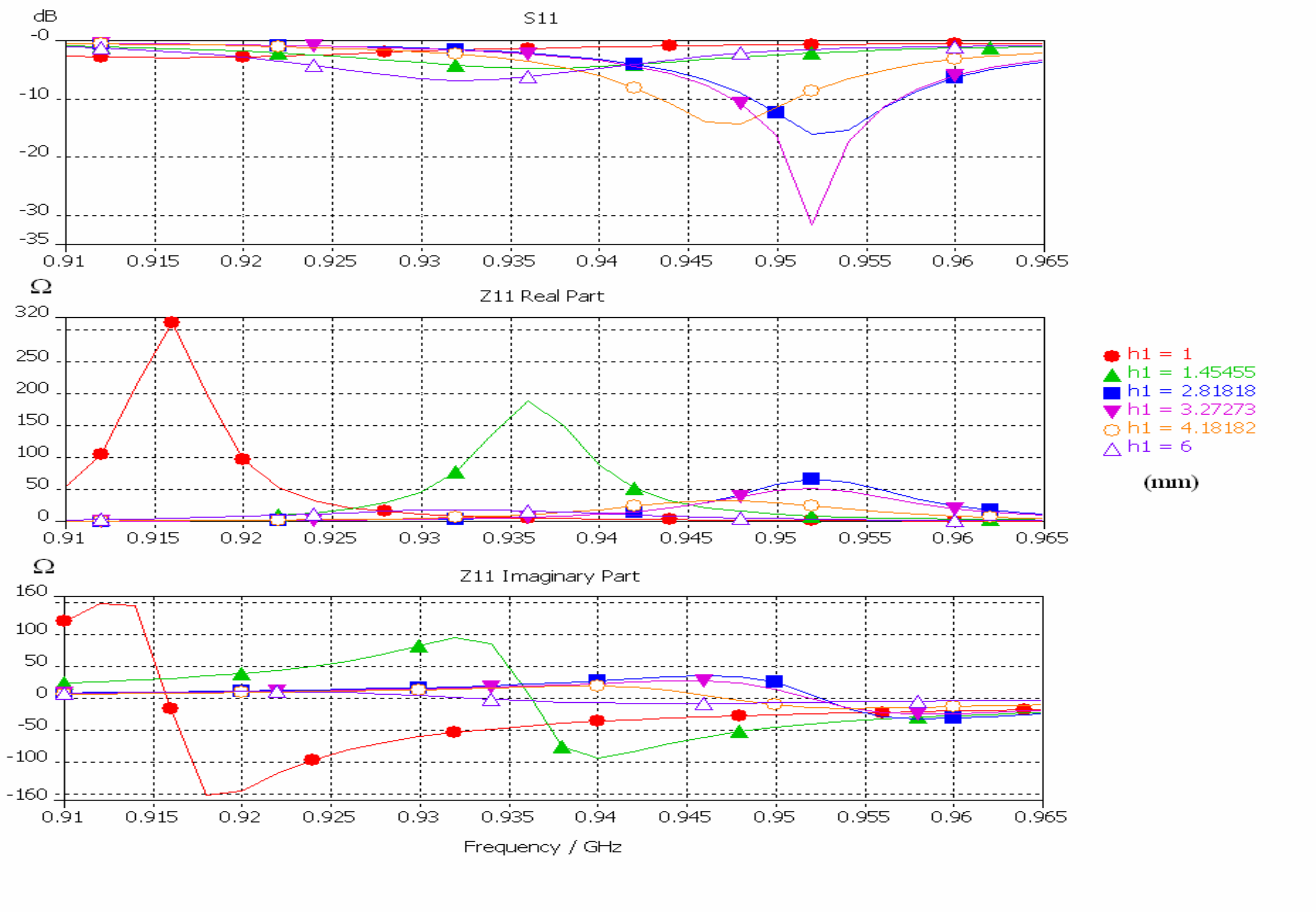
Length of coupled microstrip feed

S11(dB) and Input impedance curve of CCPA vs. L_{cf}



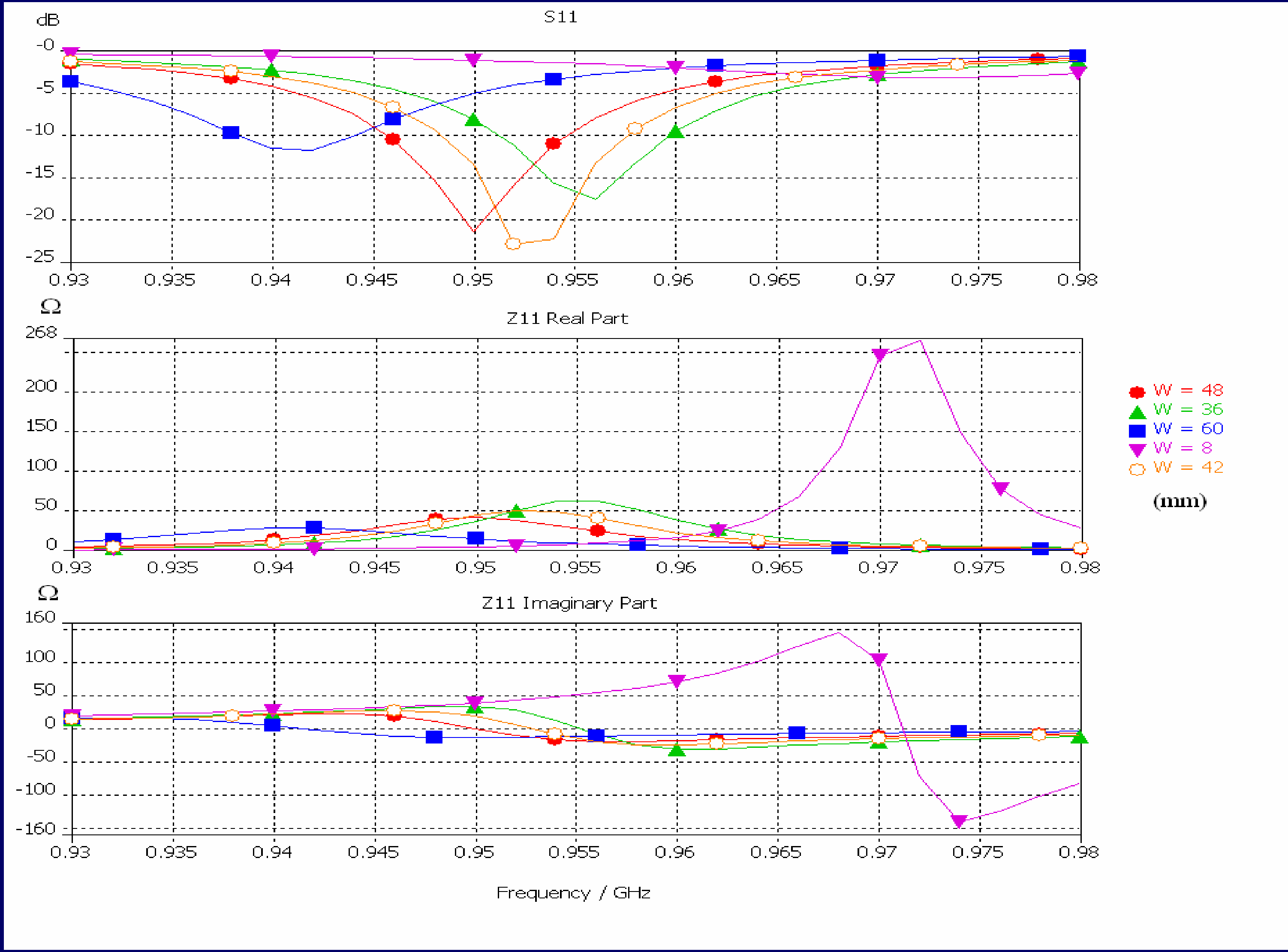
Height of air

S11(dB) and Input impedance curve of CCPA vs. h_1



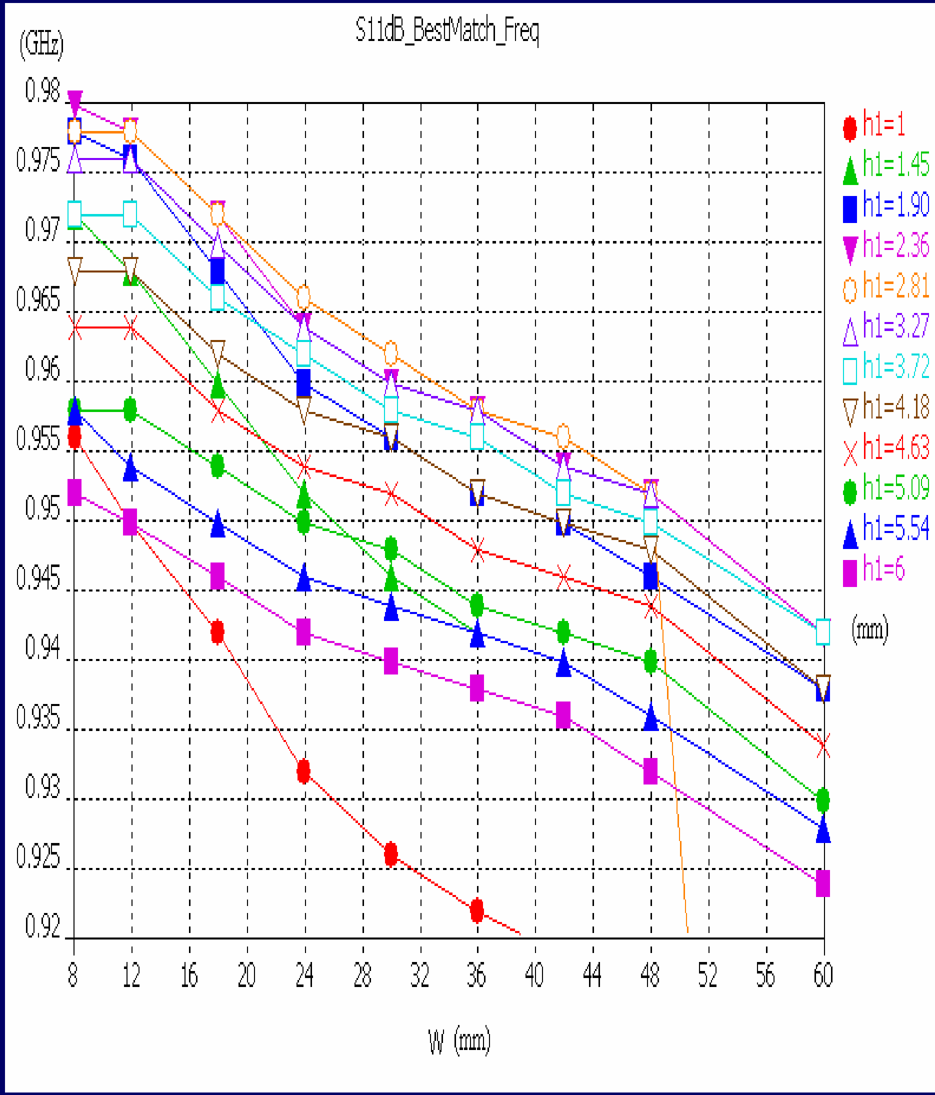
Width of quarter-wave patch

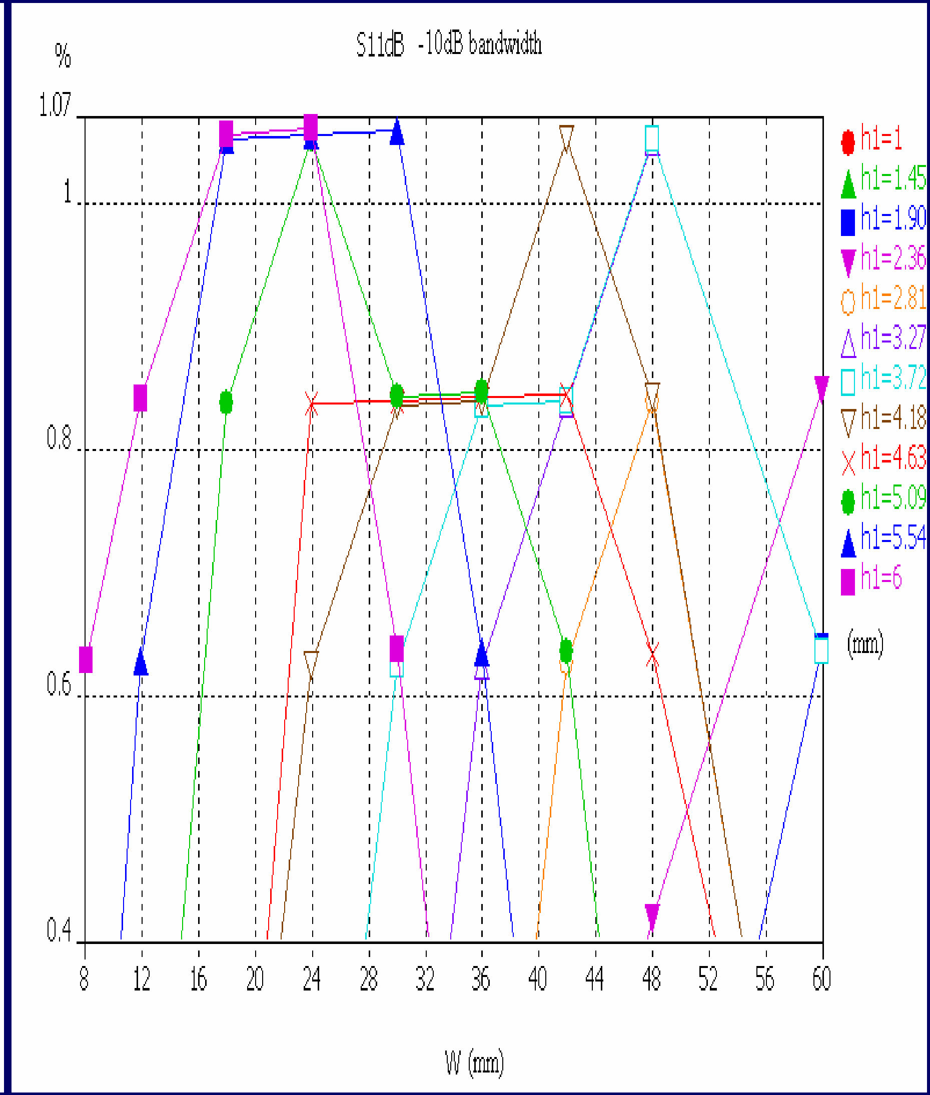
S11(dB) and Input impedance curve of CCPA vs. *W*



W and h1

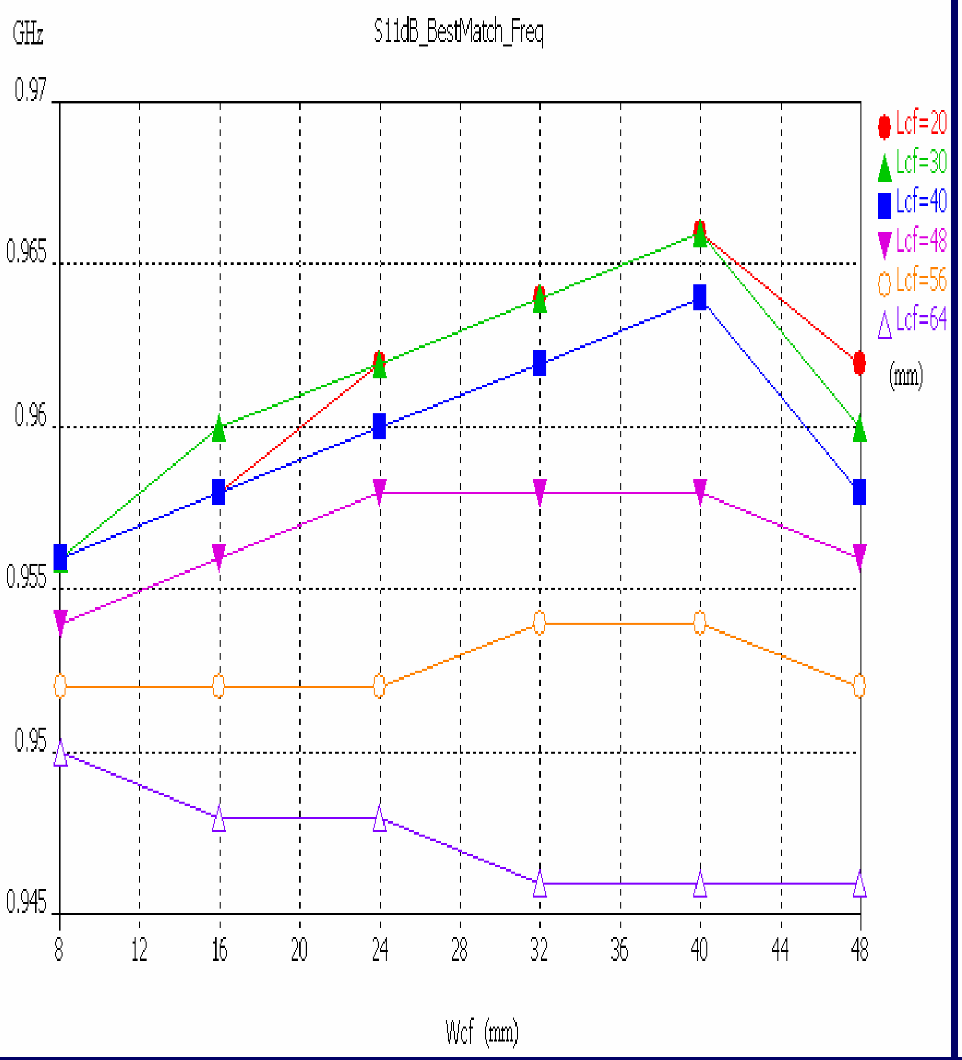
Resonant frequency and -10dB bandwidth vs. W and h_1

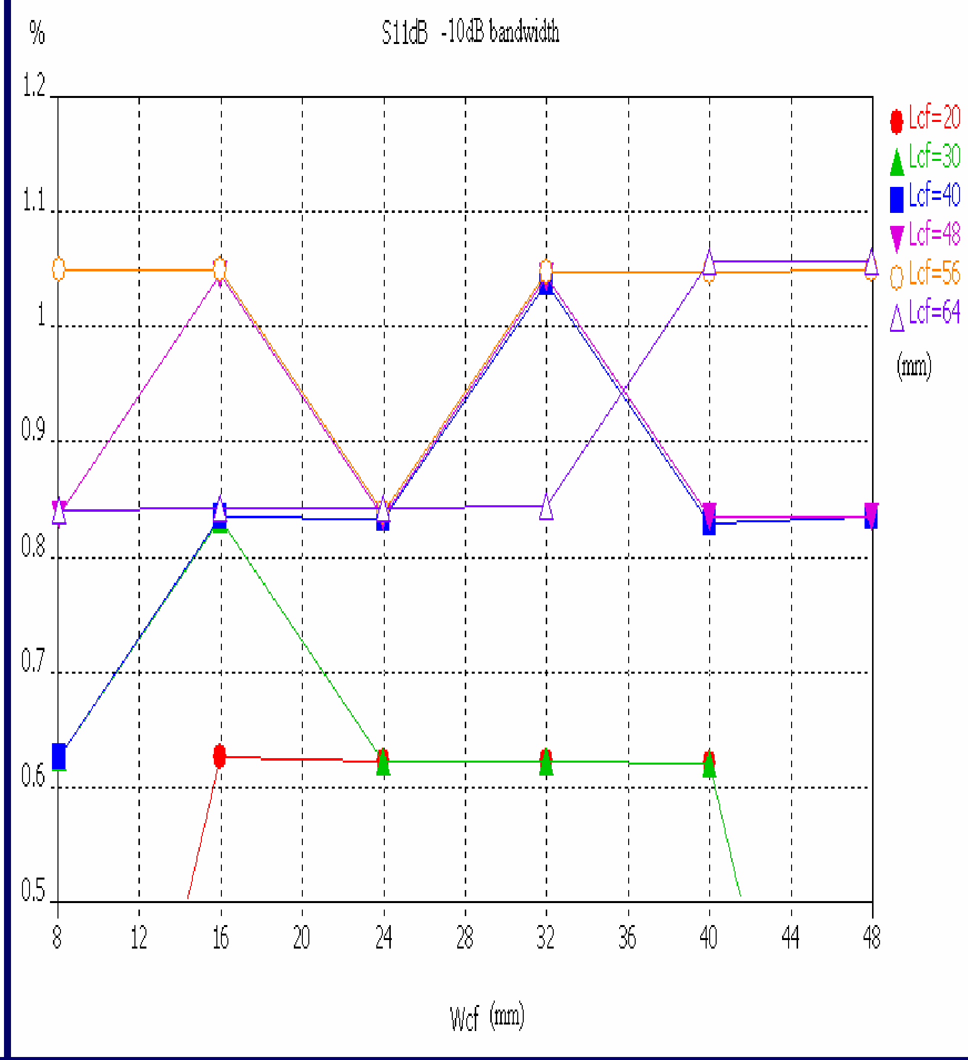




Lcf and Wcf

Resonant frequency and -10dB bandwidth vs. L_{cf} and W_{cf}

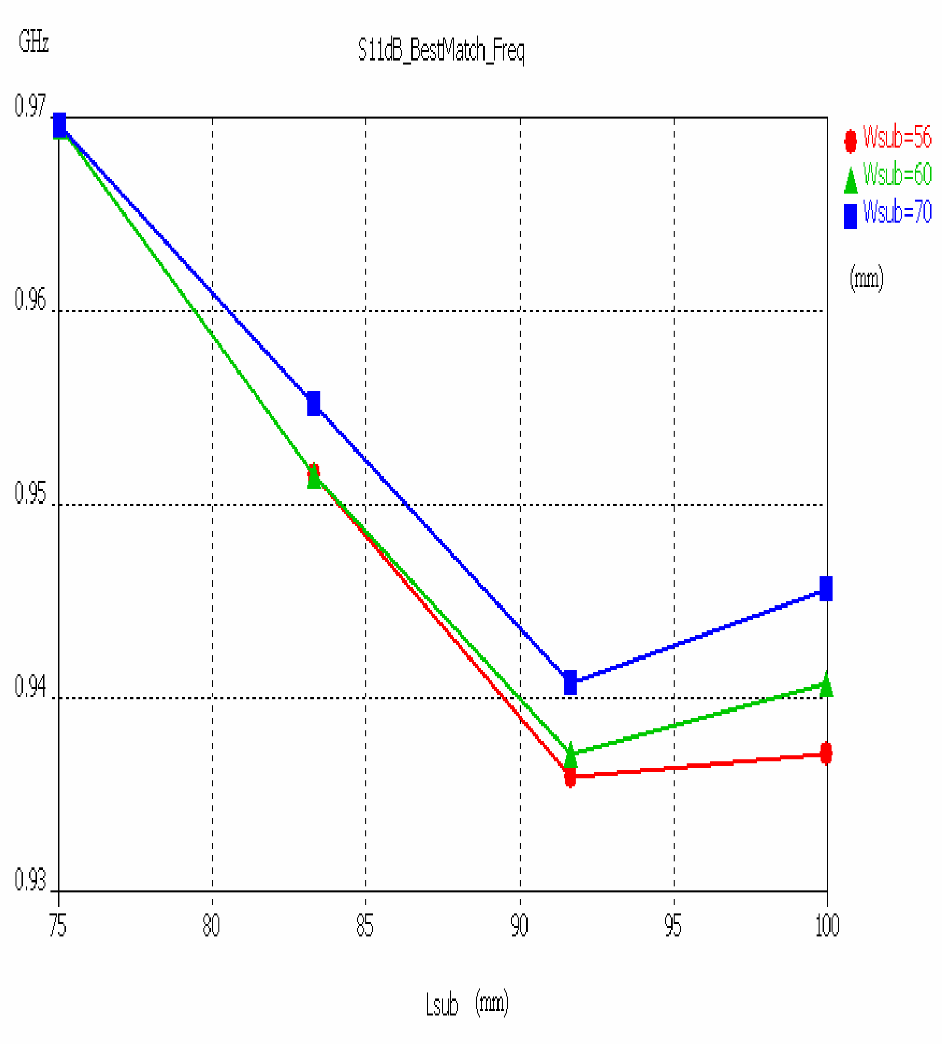


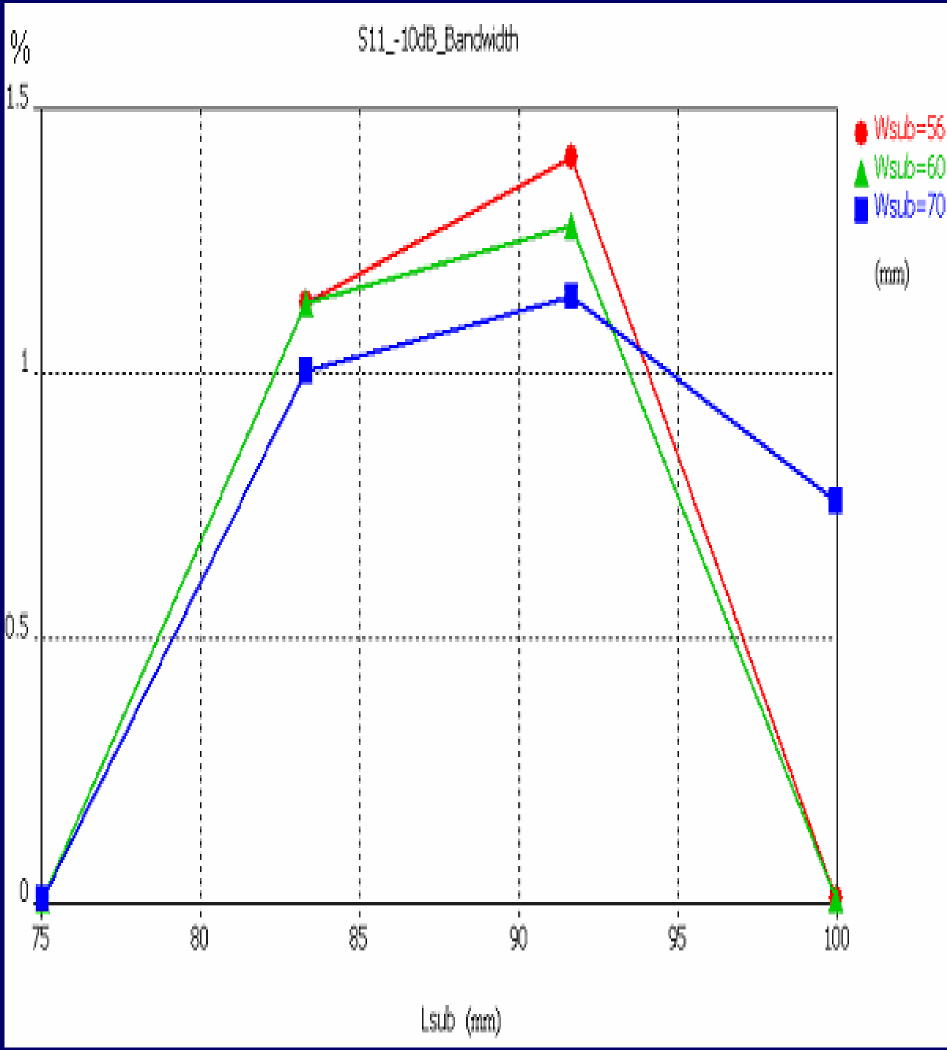


UNIVERSITÄT DUISBURG ESSEN

Lsub and Wsub

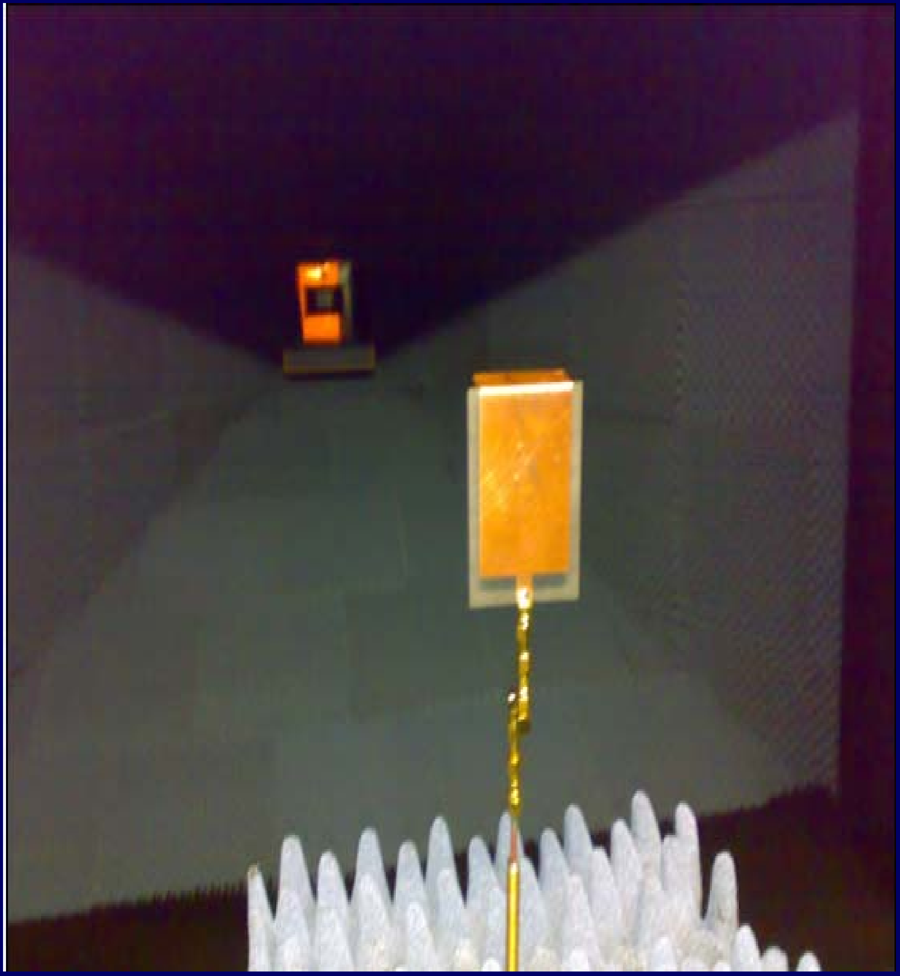
Resonant frequency and -10dB bandwidth vs. L_{sub} and W_{sub}



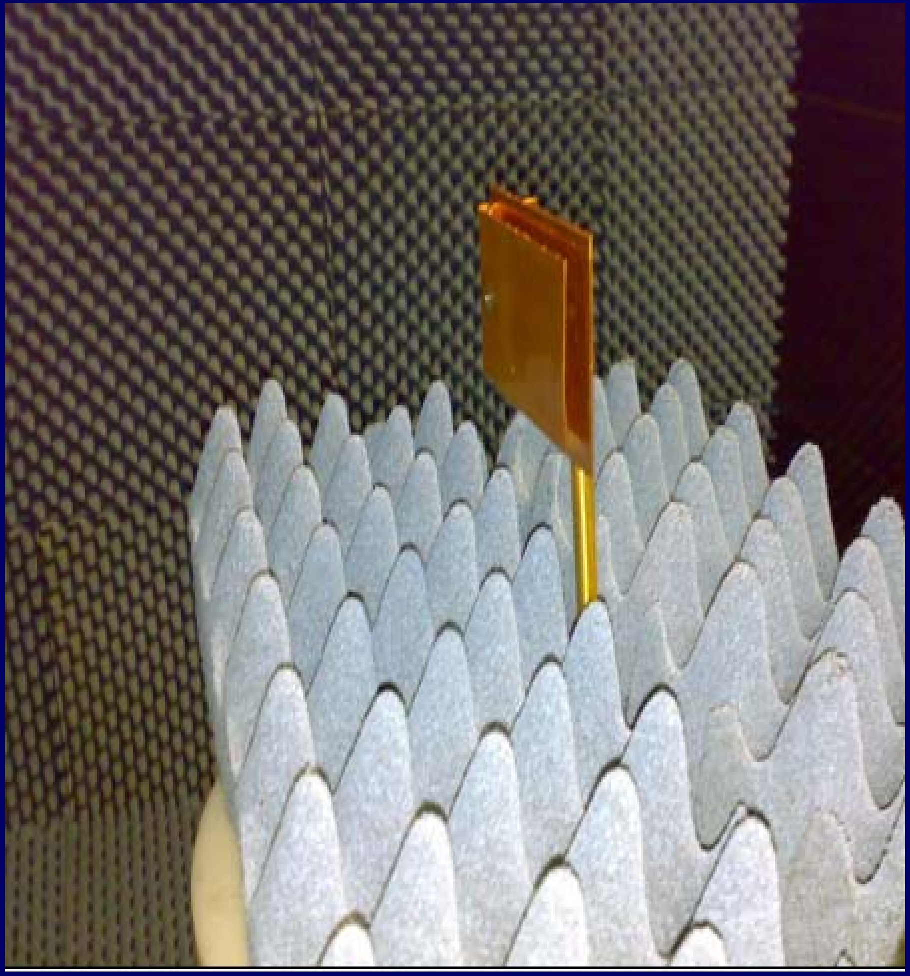


Experiment and Result

Experimental antennas

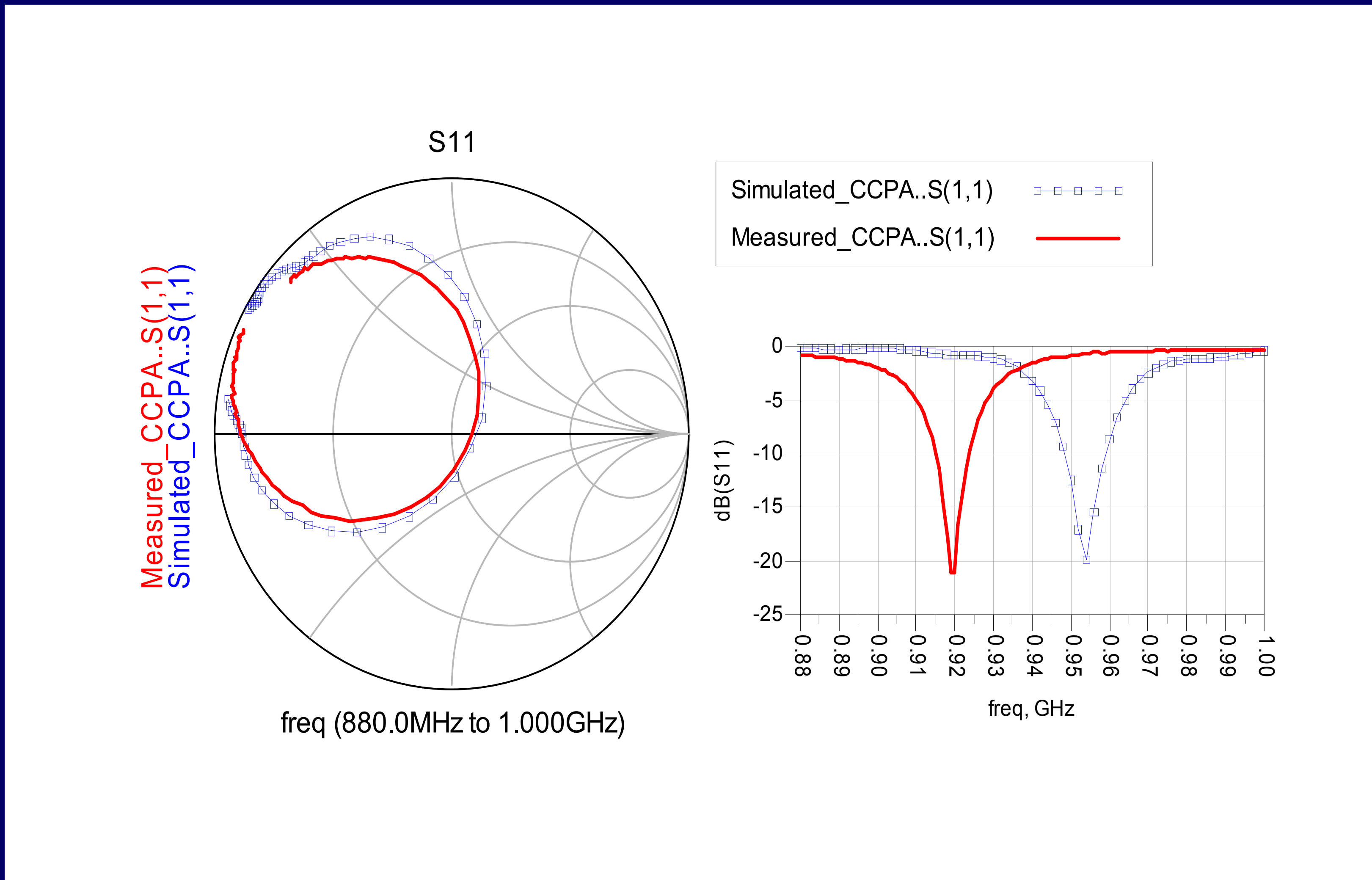


CCPA



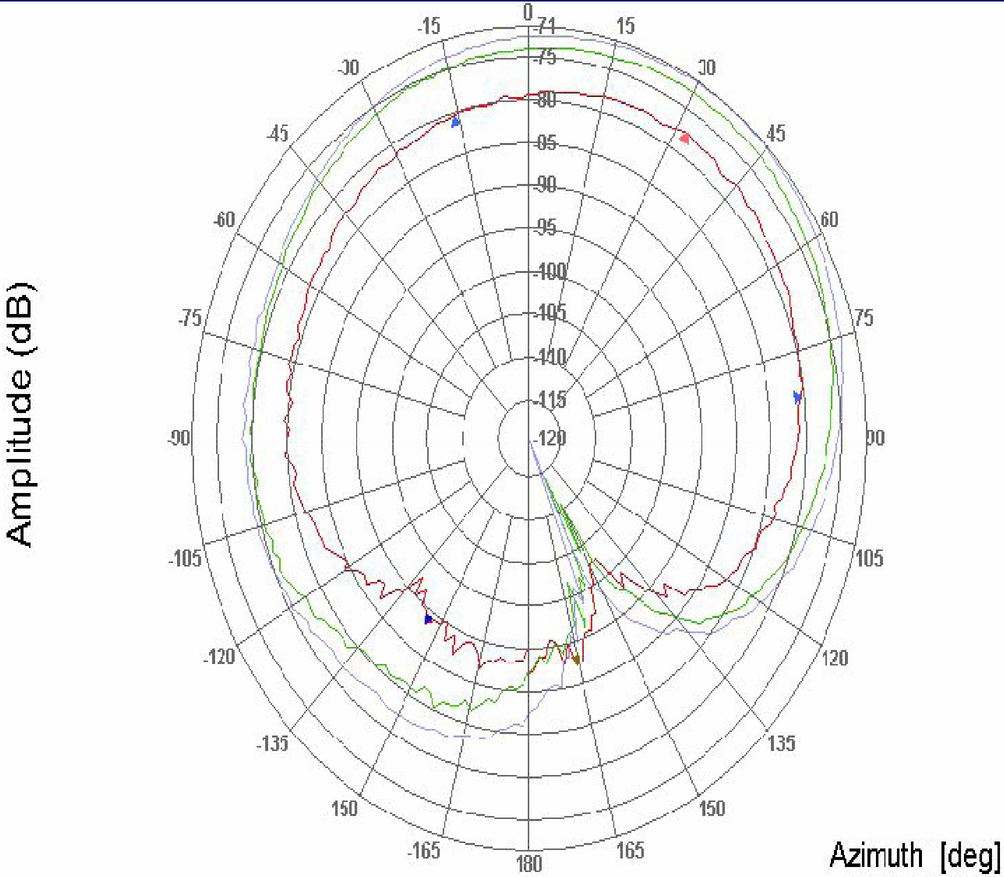
PIFA

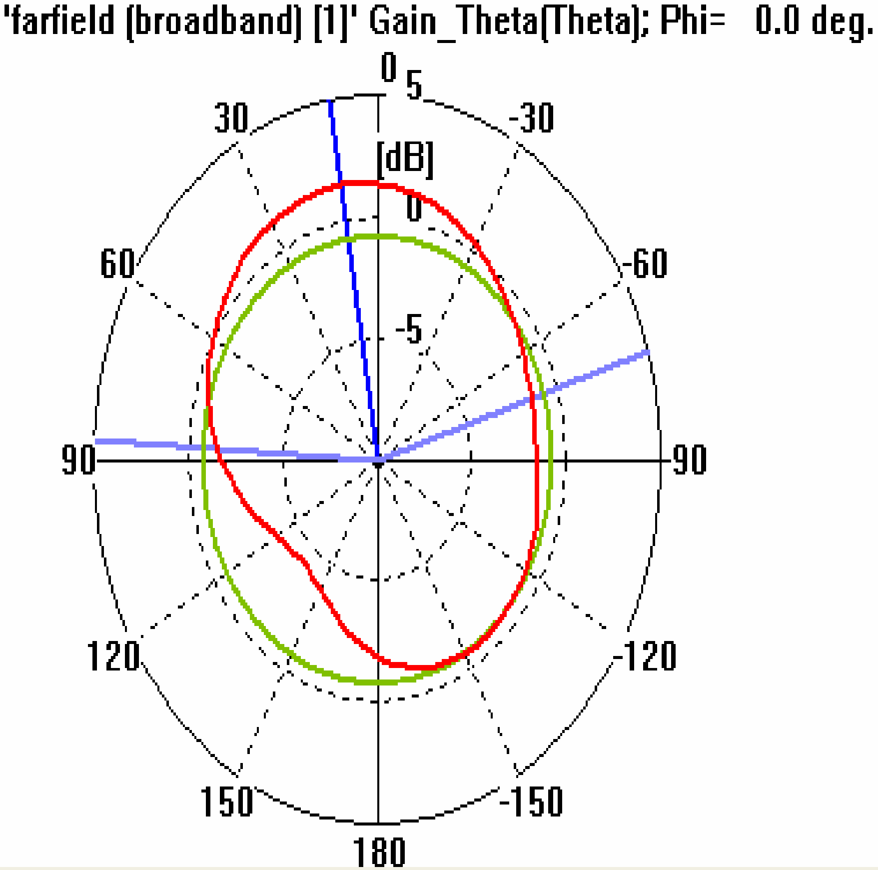
S11 of simulated and measured CCPA



Resonant frequency shift may due to the fabrication inaccuracy

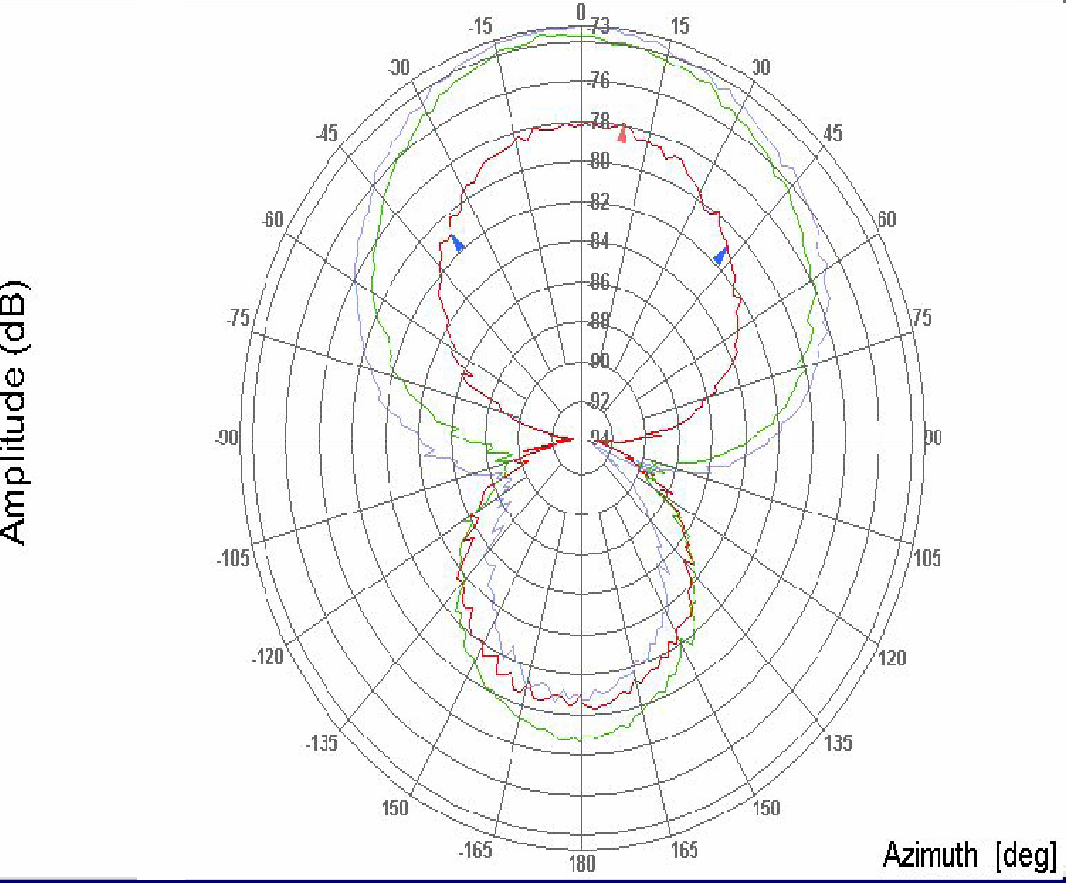
E-plane Co-polarization of CCPA

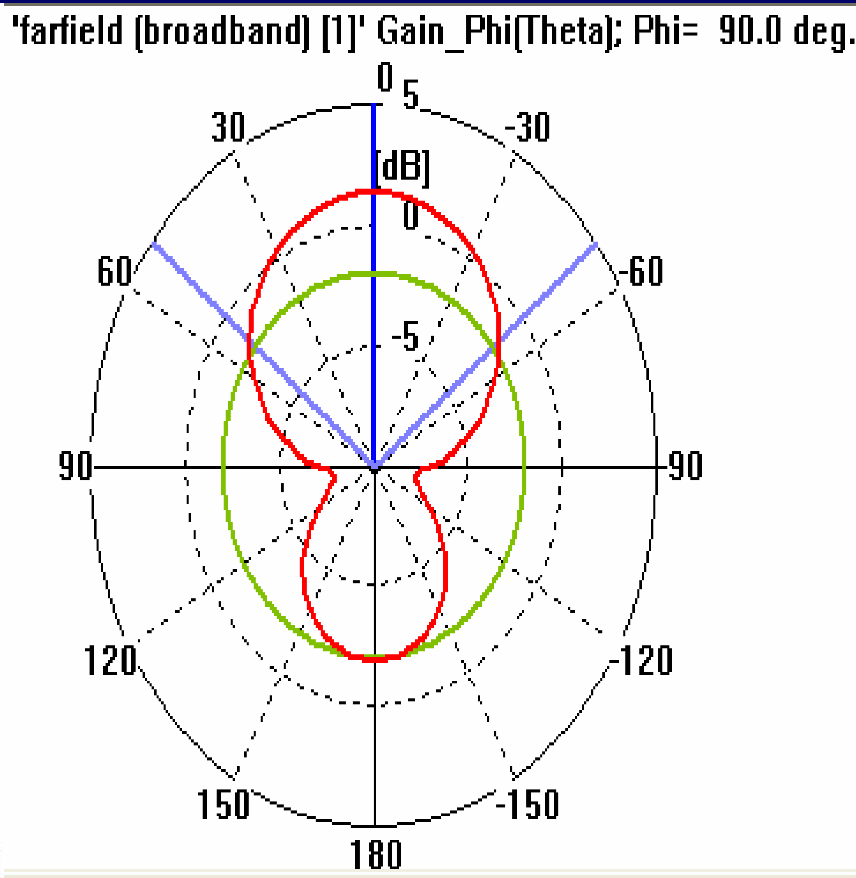




UNIVERSITÄT DUISBURG ESSEN

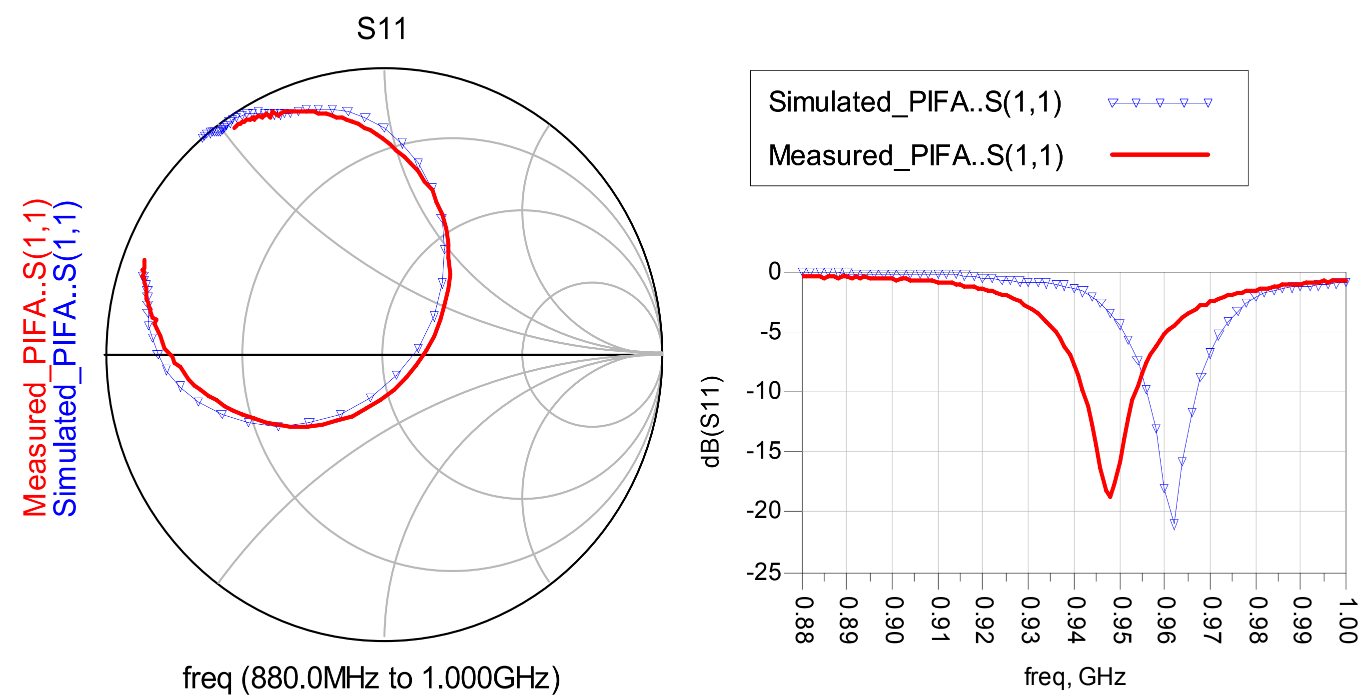
H-plane Co-polarization of CCPA





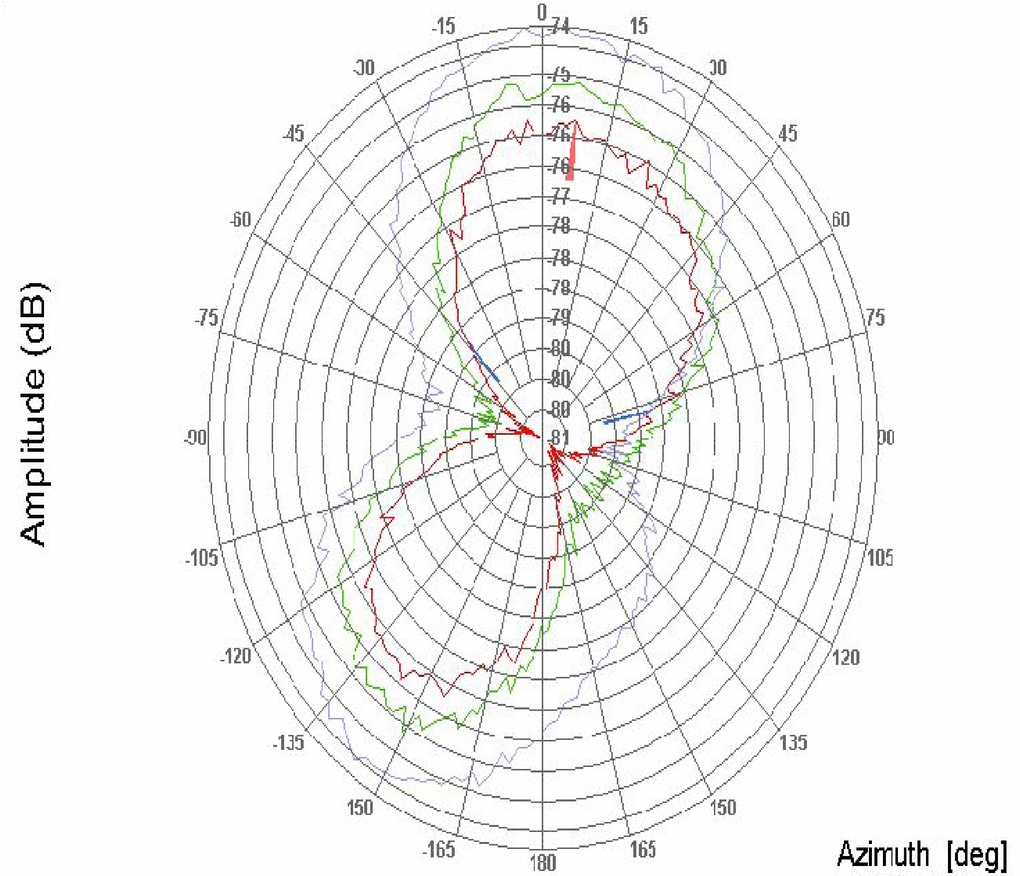
The simulated and measured radiation patterns are in good agreement.

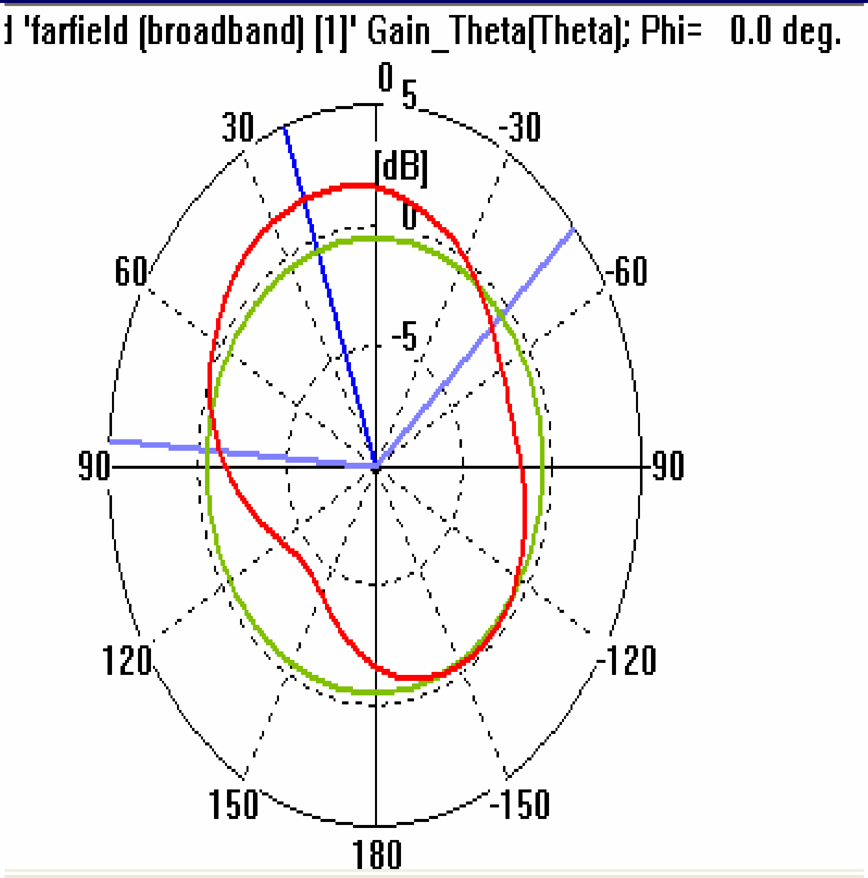
S11 of simulated and measured PIFA



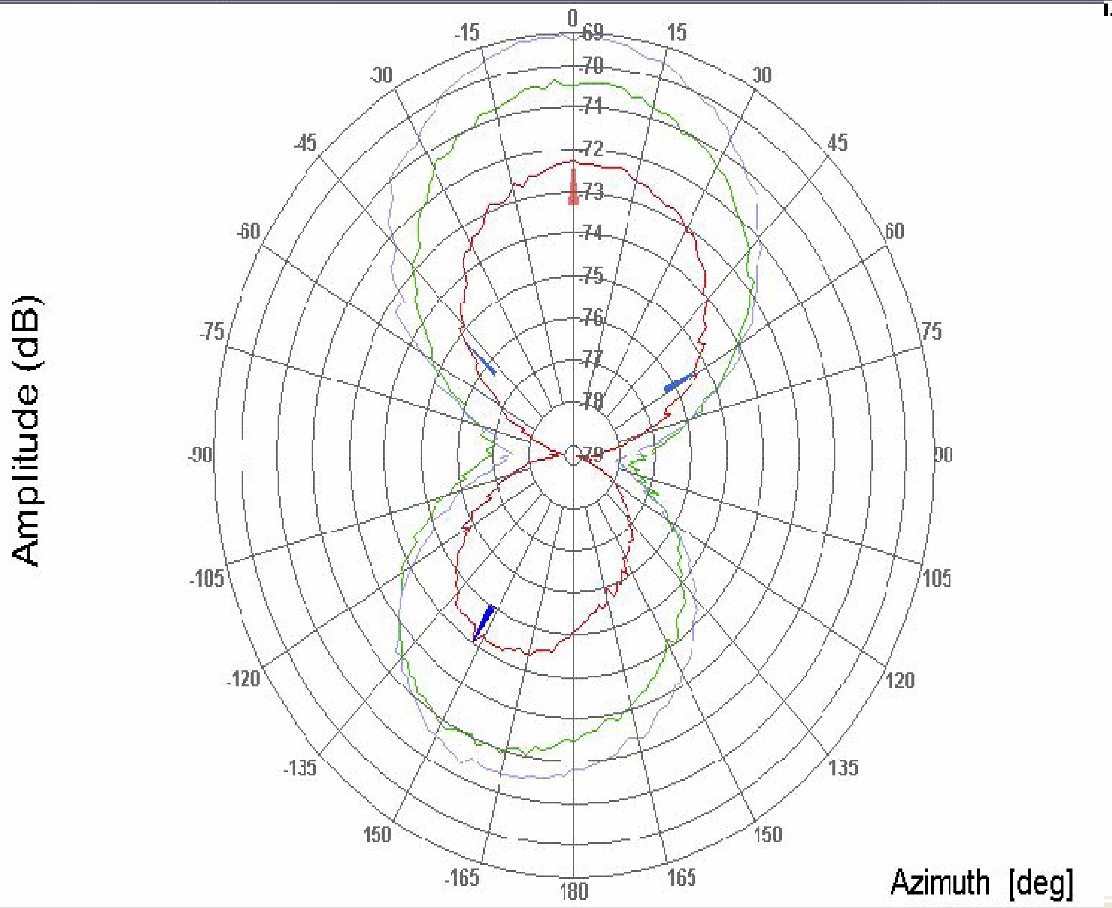
Resonant frequency shift may due to the fabrication inaccuracy

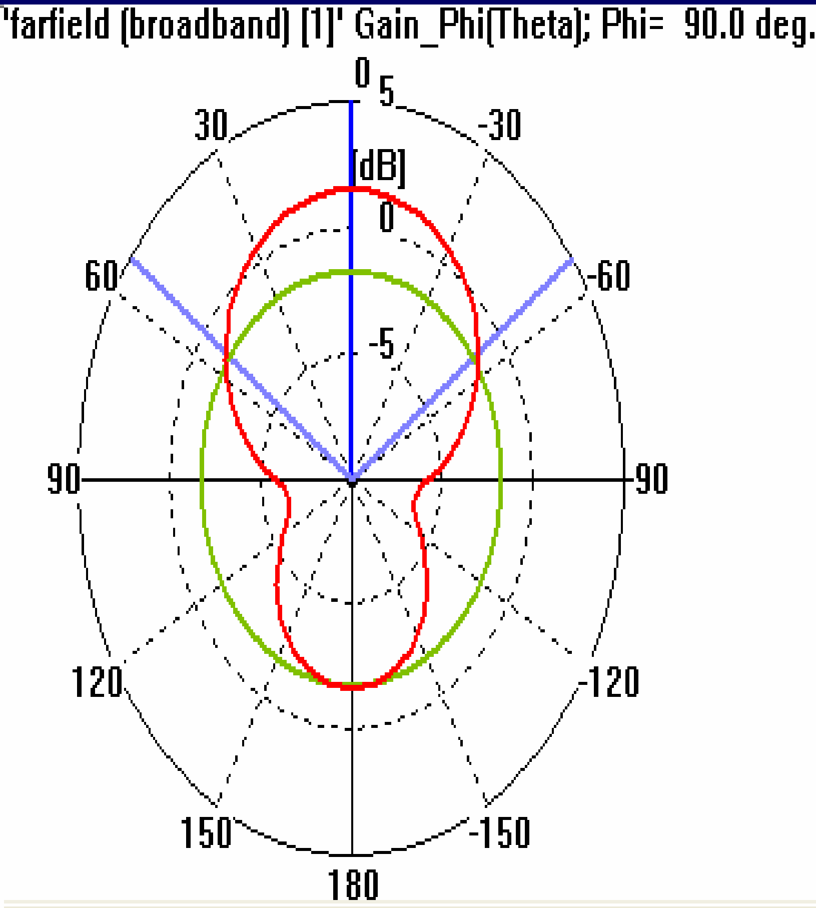
E-plane Co-polarization of PIFA





H-plane Co-polarization of PIFA





unsymmetrical pattern may due to the fabrication inaccuracy

Conclusion

[Summary of design rules for CCPA]

- A. Decide the limitation to the geometries of whole antenna
- B. Select thin and low permittivity substrate for the lower substrate of CCPA to suppress surface wave loss
- C. Choose appropriate arbitrary values for W and h_1 based on dimension limitation defined by step A as test dimensions to calculate a trial length L
- D. Make multi-parameter sweeping with W and h_1 to achieve some results versus combinations of parameters, plot their resonant frequency so as -10dB bandwidth and pick up best combination of them.
- E. Make multi-parameter sweeping with W_{cf} and L_{cf} based on decided parameters from above steps, get table of results as step D. Shift the resonant frequency to required range and adjust parameters for best bandwidth
- F. Modify the substrate dimension to achieve possible higher bandwidth (same method in D, E) within the substrate limitation defined in step A

Thanks for your attention !